(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 March 2001 (29.03.2001)

PCT

(10) International Publication Number
WO 01/22632 A1

(51) International Patent Classification[7]: H04H 1/00

(21) International Application Number: PCT/SE00/01732

(22) International Filing Date:
7 September 2000 (07.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9903365-6 20 September 1999 (20.09.1999) SE

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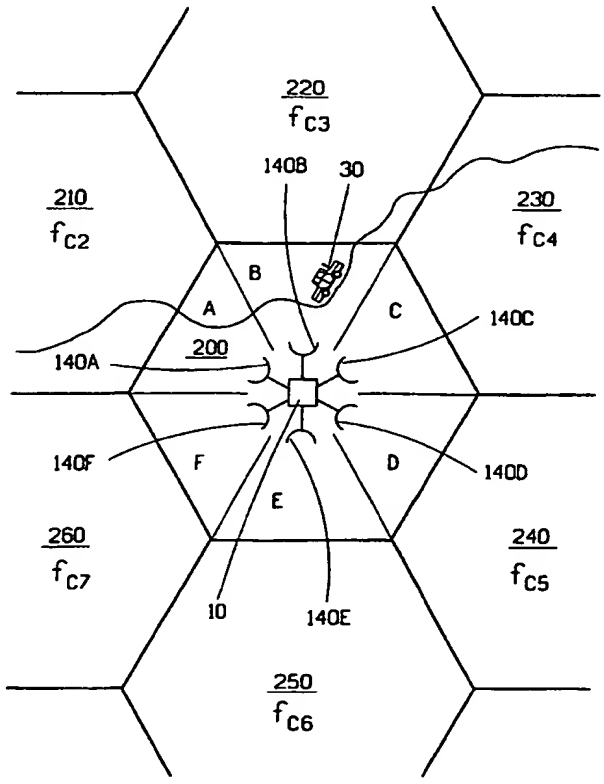
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: A BROADCASTING SYSTEM



(57) Abstract: The invention relates to a method for frequency tracking in a digital broadcasting system comprising a plurality of broadcasting transmitter stations (10) for transmitting a service to a mobile broadcast receiver (30). The method comprises the steps of: transmitting, from a certain broadcasting transmitter station (10), said service using a first central frequency (f_{C1}); transmitting, from said certain broadcasting transmitter station (10), information identifying said certain transmitter; transmitting, together with said service, a list comprising transmitter identification codes and associated alternative frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) on which said service is transmitted. The method further comprises transmitting, in a first directional sector from said certain broadcasting transmitter station, a first transmitter identification code (A); and transmitting, in a second directional sector from said certain broadcasting transmitter station, a second transmitter identification code (B), said second transmitter identification code (B) differing from said first transmitter identification code (A); wherein said list associates said first transmitter identification code (A) with a first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}), and said list associates said second transmitter identification code (B) with a second set of alternative central frequencies (f_{C2}; f_{C3}; f_{C4}), said second set of alternative central frequencies (f_{C2}; f_{C3}; f_{C4}) differing from said first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}).

WO 01/22632 A1

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A BROADCASTING SYSTEM

Technical Field of the Invention

The present invention relates to a method for frequency tracking in a broadcasting system. The invention also relates to a broadcasting transmitter station, and to a broadcast receiver.

Description of Related Art

Broadcasting systems for providing wireless services comprise a plurality of transmitters for enabling a mobile receiver to receive a selected service even if the mobile receiver moves out of the area covered by one of the transmitters. Sometimes the receiver may have to change reception frequency when leaving the coverage of one transmitter and entering the coverage of another transmitter.

The RDS-system for FM radio is an example of a system for enabling automatic frequency tracking. The Digital Audio Broadcasting (DAB) standard is another example of a standardized system for broadcasting services.

The European Telecommunication Standard document ETS 300 401, May 1997, second edition, issued by the European Telecommunications Standards Institute (ETSI) describes a conceptual block diagram of the emission part of the DAB system. Signals corresponding to a number of services, such as Audio Programme Services and general data services, are provided to an Orthogonal Frequency Division Multiplex (OFDM) signal generator providing a radio frequency signal. The radio frequency signal is mixed with a Transmission Identification Information signal so as to generate a DAB transmission signal having a TII signal indicative of the transmitter.

WO 99/14874 describes a method and a device for change of reception frequency in a digital audio broadcasting system receiver.

Summary

The present invention relates to the problem of improving the performance of a broadcasting system.

This problem is addressed by a method for frequency tracking in a digital broadcasting system comprising a plurality of broadcasting transmitter stations for transmitting a service to a mobile broadcast receiver;
the method comprising the steps of :

transmitting, from a certain broadcasting transmitter station, said service using a first central frequency;

transmitting, from said certain broadcasting transmitter station, information identifying said certain transmitter;

transmitting, together with said service, a list comprising transmitter identification codes and associated alternative frequencies on which said service is transmitted. The method further comprises the steps of :

transmitting , in a first directional sector from said certain broadcasting transmitter station, a first transmitter identification code; and

transmitting , in a second directional sector from said certain broadcasting transmitter station, a second transmitter identification code, said second transmitter identification code differing from said first transmitter identification code; wherein

said list associates said first transmitter identification code with a first set of alternative central frequencies, and

said list associates said second transmitter identification code with a second set of alternative central frequencies, said second set of alternative central frequencies differing from said first set of alternative central frequencies.

This solution improves the performance of the broadcasting system by enabling a simplified procedure for frequency change in a mobile broadcast receiver. The simplified procedure provides a reduced time duration for the frequency change, thereby eliminating or reducing the risk for interruption of the service when the mobile receiver moves from one cell to another. In particular, the mobile broadcast receiver will, on reception of the alternative frequency information, be informed about the frequencies which are most likely to provide high performance reception when the mobile receiver leaves the current frequency cell.

The provision of a unique identification code identifying, not only the transmitter, but also the cell sector covered by the directionally transmitted signal provides, to a mobile broadcast receiver, a geographic information about the position of the mobile broadcast receiver in the relevant cell. This geographic information, indicating the sector in the cell, may be used, by the mobile broadcast receiver, for establishing the frequencies of the transmitters geographically located near the current cell sector.

In the digital broadcasting system, a broadcasting transmitter station neighbouring to the certain broadcasting transmitter station in the general direction of the first directional sector transmits said service using a central frequency selected from among the first set of alternative central frequencies.

The above mentioned problem is also addressed by a broadcast receiver set up for receiving a service; comprising

an antenna for receiving a digitally transmitted service from at least one of a plurality of broadcasting transmitter stations;

an RF circuit, coupled to the antenna, for selection of a central frequency to be received by the broadcast receiver for receiving said service, said RF circuit having a control input for receiving a central frequency control signal;

a data processing unit coupled to the control input such that selection of the central frequency to be received can be controlled by the data processing unit;

a demultiplexer unit coupled to the RF circuit for extracting service identity information associated with said service, and for extracting information about alternative central frequencies;

an extraction device for extracting a currently received transmitter identification code;

a quality monitor for monitoring the quality of reception of the selected service so as to initiate a frequency change when the monitored quality falls below a certain threshold value. The data processing unit is capable of storing the information about alternative central frequencies such that a first transmitter identification code is associated with a first set of alternative central frequencies, and such that a second transmitter identification code is associated with a second set of alternative central frequencies. Furthermore, the data processing unit co-operates with the quality monitor and the RF circuit so as to cause the broadcast receiver to perform a quality initiated frequency change to reception on a central frequency in the first set when the currently received transmitter identification code is the first transmitter identification code; and so as to cause the broadcast receiver to perform a quality initiated frequency change to reception on a central frequency in the second set when the currently received transmitter identification code is the second transmitter identification code.

This solution improves the performance of the broadcasting receiver by enabling a simplified procedure for frequency change. The advantageous association of the TII code with a limited number of alternative frequencies, each having a high probability of providing good reception quality, enables the receiver to find the selected service quickly, thereby eliminating or reducing interruptions of the reception.

According to an embodiment of a method for automatic frequency tracking in a mobile broadcast receiver set up for receiving a selected service; the method comprises the steps of:

receiving information including a selected service from at least one of a plurality of broadcasting transmitter stations using a first central frequency;

extracting service identity information associated with said service;

extracting a list comprising transmitter identification codes and associated alternative frequencies on which said service is transmitted;

extracting a currently received transmitter identification code;

monitoring the quality of reception on said first central frequency.

The method also comprises the step of using the list of alternative central frequencies such that when one transmitter identification code is associated with one alternative central frequency the broadcast receiver performs a frequency change to reception on the alternative central frequency associated with the currently received transmitter identification code when the monitored quality falls below a certain threshold value.

This solution improves the performance of the broadcasting receiver by enabling a simplified procedure for frequency change. The advantageous association of the TII code with the actual frequency to which the receiver should change, when the reception quality on the current central frequency deteriorates, provides a reduced time duration for the frequency change and thereby the risk for interruptions of the selected service is eliminated or reduced. In particular the search for a suitable alternative reception frequency is avoided, thereby significantly reducing the duration of the procedure for frequency change.

According to an embodiment the mobile broadcast receiver is adapted to use the currently, or most recently, received Transmitter Identification Information (TII) as a key to a look-up table (LUT), the LUT comprising a plurality of frequencies used for the relevant service. The LUT delivers the frequency of the closest broadcasting transmitter station for the relevant service in response to the unique identification code.

An embodiment of the method for automatic frequency tracking in a mobile broadcast receiver includes the steps of:

evaluating the list for establishing whether the received list includes a single alternative central frequency or plural alternative central frequencies associated with the current transmitter identification code;

performing a frequency change so as to continue reception of the selected service on the alternative central frequency when the list includes a single alternative central frequency;

performing at least one test reception, when the list includes plural alternative central frequencies, for evaluating the reception quality of the plural alternative central frequencies so as to select an alternative central frequency providing an acceptable reception quality. This embodiment advantageously provides compatibility with transmitters of both types, the improved frequency change being used when the receiver moves out of a cell with a transmitter sending the list according to the invention

According to an embodiment of the broadcasting system a transmitter station uses a common OFDM signal generator for delivering an OFDM signal s(t) to a plurality of transmission units. The provision of a plurality of transmission units coupled to a single OFDM signal generator reduces the costs of the improved system. In effect the amount of electronic hardware and software is reduced, thereby reducing the costs, since the same OFDM signal s(t) is used for all the transmission units instead of providing separate OFDM signal generators for each transmission unit.

Brief Description of the Drawings

For simple understanding of the present invention, it will be described by means of examples and with reference to the accompanying drawings, of which:

Figure 1 illustrates a geographic area in which a plurality of broadcasting transmitter stations are provided.

Figure 2 illustrates an embodiment of a transmitter station.

Figure 3 illustrates a DAB transmission signal in the time domain, including a Synchronization Channel.

Figure 4A is an example of a Synchronization Channel of Figure 3, illustrated in the frequency domain.

Figure 4B is another example of a Synchronization Channel of Figure 3, illustrated in the frequency domain.

Figure 4C illustrates an embodiment of the method of operation of the broadcasting transmitter station of Figure 2.

Figure 5 is a more detailed illustration of a cell, as shown in Fig 1, having a broadcasting transmitter station according to an embodiment of the invention.

Figure 6 is a block diagram of a broadcast receiver adapted for receiving the DAB transmission signals, and capable of performing a simplified procedure for frequency change.

Figure 7 illustrates an embodiment of a procedure for frequency change during reception of a service using a receiver as shown in Fig 6.

Figure 8 illustrates another embodiment of a procedure for frequency change during reception of a service using a receiver as shown in Fig 6.

Detailed Description of Embodiments

In the following description similar features in different embodiments will be indicated by the same reference numerals.

Figure 1 illustrates a geographic area in which a plurality of broadcasting transmitter stations 10 are provided. Each broadcasting transmitter station 10 transmits a radio signal having a carrier frequency with a certain bandwidth. Each station 10 provides radio coverage for a certain part 20 of the area, a so called cell 20. In a typical case all the stations 10 provide the same service so that a mobile broadcast receiver 30 may move between the cells 20 while receiving the same radio service, i.e. without losing the reception of the selected radio service.

Hence, a broadcast receiver 30 located in the area may be set to receive a broadcast service provided by the broadcasting transmitter stations 10. The mobile receiver 30 will demodulate/decode the service from the broadcasting transmitter station 10 which provides the service with the best reception quality.

According to an embodiment of the invention the same service may be provided on mutually different frequencies by two mutually adjacent cells 20. Hence, the mobile receiver 30 will have to change reception frequency when moving out of one cell 20 and into another one, in order to maintain an uninterrupted reception of the selected service.

For the purpose of enabling automatic frequency tracking each broadcasting transmitter station 10 transmits information indicative of an alternative frequency on which said service is transmitted. The receiver 30 measures the quality of the received service and when the quality is lower than a predetermined threshold value the receiver 30 will perform a frequency transition procedure so as to switch the reception over to the alternative frequency without interrupting the reception of the service. This is described in further detail later in this document.

Figure 2 illustrates an embodiment of a transmitter station 10. The transmitter station 10 includes inputs 40, 42, 44, 46, 48 for information to be transmitted. The input 40 may be an input for service information coupled to a service information assembler 50. The input 42, for analogue sound signals, is coupled to an A/D-converter and MPEG-encoder 52. There may be several inputs 42 coupled to the MPEG-encoder 52. Inputs 44, 46, 48 are digital data inputs coupled to a packet multiplex assembler 54. The outputs of devices 50 52 and 54 are coupled to an main service multiplexer 60 which operates to deliver a serial digital output. The serial digital output, constituting a Common Interleaved Frame (CIF) is delivered to an Orthogonal Frequency Division Multiplex (OFDM) signal generator 70. The OFDM signal generator 70 includes an RF-modulator . Also connected to the OFDM signal generator 70 is a synchronization channel symbol generator 80, and a Fast Information Block assembler 82.

The OFDM signal generator 70, on its output 90, delivers a radio frequency (RF) signal s(t). According to embodiments of the invention the OFDM signal s(t) is delivered to a plurality of transmission units 100. In the embodiment illustrated in Fig. 2 the OFDM signal s(t) is delivered to three different transmission units 100A, 100B and 100C, respectively.

Each transmission unit 100 includes a device 110 for mixing the radio frequency signal s(t) with a Transmission Identification Information signal $S_{TII}(t)$ so as to generate a DAB transmission signal $S_{DAB}(t)$. The transmission unit 100A includes a first TII signal generator 120A providing a first Transmission Identification Information signal $S_{TIIA}(t)$ comprising a first identity code TII_A.

The DAB transmission signal $S_{DABA}(t)$ is amplified by a power amplifier 130A and the resulting signal is delivered to a directive antenna 140A. In the same manner the transmission unit 100B delivers a DAB transmission signal $S_{DABB}(t)$ to another

directive antenna 140B; and transmission unit 100C delivers a DAB transmission signal $S_{DABC}(t)$ to a directive antenna 140C. The transmission signals $S_{DABA}(t)$, $S_{DABB}(t)$ and $S_{DABC}(t)$ are synchronized with respect to time and frequency, i.e. the signals are identical except for the TII code.

The DAB transmission signal $S_{DABA}(t)$, delivered by the device 110A, is a time divided signal. Figure 3 illustrates the signal $S_{DABA}(t)$ in the time domain. The signal comprises a sequence of frames 150 corresponding to the juxtaposition in time of a Synchronization Channel 160, a Fast Information Channel (FIC) 170, and a Main Service Channel (MSC) 180. The duration of the transmission frame 150 is denoted by T_F.

Each transmission frame 150 is divided into a sequence of OFDM symbols, each symbol comprising a number of carriers. The Synchronization Channel 160 comprises the Transmitter Identification Information TII, as mentioned above, and as described in European Telecommunication Standard document ETS 300 401, May 1997, second edition, the content of which is hereby incorporated by reference.

Figure 4A is an example of the Synchronization Channel 160, illustrated in the frequency domain. The Synchronization Channel 160 comprises a first identity code TII_A. The first identity code TII_A comprises a number of carriers having a unique combination of frequencies. The frequency combination of the carriers may be used for identifying the transmission unit 100A, 100B, 100C. The carrier frequency combination shown in Fig 4A may for example constitute the first identity code TII_A delivered by the first TII signal generator 120A in Fig 2. In a corresponding manner the carrier frequency combination shown in Fig 4B may constitute the identity code TII_B delivered by the TII signal generator 120B in Fig 2.

Figure 4C illustrates an embodiment of the method of operation of the broadcasting transmitter station 10. In a first step S10 the service data is received via input 40, 42,

44, 46 and/or 48. In a step S15 there is generated data for indicating to a receiver the alternative central frequencies on which the service is available. This data is introduced into the DAB signal by the FIB assembler 82 (See Fig. 2). This data includes information for enabling a receiver to recognise a plurality of TII codes, and information for correlating an individual TII code with a single alternative central frequency, as described in connection with Table 1 below. This generated data is included in the Fast Information Block, which is included in the FIC 170 (Fig 3).

The received data from inputs 40-48 and the TII/frequency information is encoded (step S20), as described above, so as to provide an OFDM signal. The OFDM signal s(t) is delivered (step S30) to a plurality of transmission units 100, e.g. to three different transmission units 100A, 100B and 100C, as illustrated in Fig. 4C and in Fig. 2.

In the subsequent step S40 a plurality of mutually different TII codes are added to the OFDM signal s(t) in the different transmission units 100A, 100B and 100C so as to generate mutually different, but time synchronized and frequency synchronized, DAB transmission signals $S_{DABA}(t)$, $S_{DABB}(t)$, $S_{DABC}(t)$. The resulting DAB transmission signals $S_{DABA}(t)$, $S_{DABB}(t)$, $S_{DABC}(t)$ are delivered (step S50) to mutually different directive antennae 140, each directive antenna being set up to cover a part of the same cell 20 (Fig 5).

In this manner a transmitter station 10 having one OFDM signal generator 70 coupled to a plurality of transmission units 100 and a plurality of directive antennae 140 is capable of delivering a service via DAB transmission signals $S_{DAB}(t)$ such that a simplified procedure for frequency change is enabled in a mobile broadcast receiver. The directive antennae 140 which are coupled to the one OFDM signal generator 70 are mounted geographically near the OFDM signal generator 70 such that the directive antennae 140 cover different, or only partially overlapping,

portions of the geographic area around the position of the OFDM signal generator 70.

The DAB transmission signal $S_{DABA}(t)$ includes data defining a list of alternative frequencies on which the same service is available, as mentioned above. According to an embodiment of the invention each transmission unit 100A, 100B, 100C transmits a list comprising a service identifier S1, associated TII codes and alternative frequencies on which said identified service is transmitted. The list may comprise one or several alternative frequencies. An example of such information is illustrated in **Table 1** below.

According to an embodiment of the invention the transmitted list comprises a plurality of alternative central frequencies on which said identified service S1 is transmitted; wherein each TII code is associated with only one alternative frequency. The reduction of the number of alternatives related to one TII code has the advantageous effect of enabling a faster and more efficient frequency transition procedure. This will be further described with reference to Figures 7 and 8 below.

Figure 5 is a more detailed illustration of a cell 20, as shown in Fig 1, having a broadcasting transmitter station 10 according to an embodiment of the invention. The depicted cell is here referred to as cell 200, and the adjacent cells are denoted 210, 220, 230, 240, 250 and 260. The broadcasting transmitter station 10 comprises six transmission units coupled to directive antennae 140A, 140B, 140C, 140D, 140E and 140F, respectively, so as to provide an individual TII-code for each cell segment bordering to an adjacent cell 20. The TII-codes are illustrated by capital letters A, B,C, D, E and F in Fig 5. The transmitter station 10 shown in Fig 5 transmits a selected radio service S1 on a first central frequency f_{C1}.

The cell 210 which is adjacent to cell segment A of cell 200 delivers the selected radio service S1 on a second central frequency f_{C2}, deviating from the first central

frequency f_{C1}. In the same manner that radio service S1 is provided by transmitters operating on central frequencies f_{C3} f_{C4}, f_{C5}, f_{C6} and f_{C7} in the adjacent cells 220, 230, 240, 250 and 260, respectively.

The transmitter 10, operating on central frequency f_{C1}, in cell 200 delivers a list of TII codes and associated adjacent central frequencies f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6} and f_{C7}. The list may be used as a look up table (LUT) as illustrated in table 1 below.

Service	**Received TII-code**	**Alternative frequency**
S1	A	f_{C2}
S1	B	f_{C3}
S1	C	f_{C4}
S1	D	f_{C5}
S1	E	f_{C6}
S1	F	f_{C7}

Table 1

Figure 6 is a block diagram of a broadcast receiver 30 adapted for receiving the DAB transmission signals $S_{DAB}(t)$, and capable of performing a simplified procedure for frequency change.

The receiver 30 comprises an antenna 310 coupled to an RF demodulator 320. The output of the RF demodulator 320 is coupled to a Fast Fourier Transform (FFT) unit 330, operating to deliver a stream of data on a first output 335 coupled to a Viterbi decoder 340. The FFT-unit 330 also includes a TII signal extracting device 345 operating to deliver the currently received transmitter identification code TII on a second output 348.

The Viterbi decoder 340 has a first output 350 for delivering data to a Demultiplexer 360. The Demultiplexer 360 has one or several user data outputs 370 for delivering data corresponding to that described in connection with devices 50, 52 and 54 above. The user data may be treated by dedicated circuitry 380 so as produce audio signals suitable for delivery to a loudspeaker 390, and/or so as to produce signals suitable for delivery to a display unit 392. Hence, a user may enjoy a selected service received via the loudspeaker 390 and/or the display unit 392.

The Demultiplexer 360 also has a second output 400 for delivering the data received via the FIC 170. This data is referred to as Fast Information Block (FIB), and it includes the information about alternative central frequencies and associated TII-codes. The output 400 is coupled to a data processing unit 410 via a data bus 420.

The data processing unit 410 is also coupled to a read/write memory 430 via a data bus 440. The read/write memory 430 may be used for storing and maintaining a database including a Look Up Table (LUT) as discussed in connection with **Table 1** above.

A non-volatile memory 450 is provided with a computer program for causing the data processing unit 410 to perform the method steps described below. The non-volatile memory 450 is coupled to the data processing unit 410 via a databus 460.

According to an embodiment the data processing unit 410 is coupled to receive data error information from a second output 470 of the Viterbi decoder 340.

The data processing unit 410 is also coupled to a control input 480 of the RF demodulator 320 such that selection of the central frequency to be received can be controlled by the data processing unit 410. The data processing unit 410 is also coupled to the output 348 of the TII signal extracting device 345 such that the currently received transmitter identification code TII can be monitored frequently.

According to an embodiment the data processing unit 410 frequently reads the transmitter identification code TII from output, and the value is stored in a memory location 428 of memory 430. In this manner the last received TII will be memorized so that it can be used for information about the last known position of the receiver in case the reception signal is lost.

Figure 7 illustrates an embodiment of a procedure for frequency change during reception of a service using a receiver as shown in Fig 6. It is assumed that the receiver has been set for reception of a selected service on a first central frequency f_{C1} when the illustrated procedure starts.

In a step S510 the receiver 30 receives frames 150, as described above. In step S520 the FIB data is extracted by the demultiplexor 360, and the data relating to alternative frequencies (compare step S15 above) is extracted. A Look Up Table (LUT) is generated, and the LUT is stored in the memory 430.

The reception quality is monitored, and the detected quality value is compared to a quality threshold value (step S540). As long as the detected quality value is above the quality threshold value the receiver 30 will keep receiving frames on the same central frequency (step S550), which means that the procedure will be repeated from step S510 as described above. If the detected quality value is below the quality threshold value the receiver will proceed with step S560.

In step S560 the current TII code will be read by processor 410. The current TII code will usually be the TII code currently being received, but it may also be a stored copy of TII code last received, such that if the reception is suddenly interrupted the receiver will have a copy of the last received TII code. When the receiver 30 is located as illustrated in Fig 5 this means that the processor will read TII code B. Using the code B as key to the LUT, the processor 410 then proceeds to identify the alternative frequency f_{C3} (step S570). Then processor 410 sends an instruction to

the control input 480 so as to set the RF demodulator 320 for reception of the selected service on the alternative central frequency f_{C3} (step S580). Thereafter the procedure is repeated from step S510, but now receiving the selected service on central frequency f_{C3}. In this manner a quick and efficient frequency change is obtained.

According to an embodiment of the invention steps S540 and S550 include analysis of an error rate on the data delivered by output 470 of the Viterbi decoder 340 (See Fig 6). The quality threshold value is selected such that the processor 410 will effect a frequency change when the error rate on the data delivered by output 470 indicates that a higher error rate would cause errors detectable on the user data output 370.

According to another embodiment steps S540 and S550 include analysis of the field strength of the carriers in the Synchronization Channel 160. Figure 4B illustrates received carriers having a lower field strength than the received carriers illustrated in Fig 4A. The received carrier field strength is compared with a field strength threshold value according to that embodiment of step S550.

According to yet another embodiment, steps S540 and S550 include an analysis of a carrier-to-noise ratio (C/N ratio), i.e. an analysis of the relation between the desired signal level and the inherent noise level. Another embodiment includes an analysis of the carrier-to-interference ratio (C/I ratio). The C/I ratio and the C/N ratio analysis is based on the signals on the antenna input. The monitoring of the reception quality of the selected service may also include a combination of these measures.

In the foregoing it has been assumed that a receiver is used in areas where the transmitters provide lists with a single alternative frequency associated with each TII code, as illustrated in Table 1. According to another embodiment of the DAB

broadcasting system, however, some , or all, transmitters provide lists including several alternative frequencies associated with a single TII code (see Table 2 below).

Service	Received TII-code	Alternative frequencies
S1	A	f_{C2}; f_{C3}; f_{C7}
S1	B	f_{C2}; f_{C3}; f_{C4}
S1	C	f_{C3}; f_{C4}; f_{C5}
S1	D	f_{C4}; f_{C5}; f_{C6}
S1	E	f_{C5}; f_{C6}; f_{C7}
S1	F	f_{C6}; f_{C7}; f_{C2}

Table 2

In the embodiment illustrated by Table 2 each of the directional antennae transmitting on a certain frequency will indicate a subset of alternative frequencies so as to maximise the probability of indicating a frequency with a good reception quality.

Figure 8 illustrates another embodiment of a procedure for frequency change during reception of a service using a receiver as shown in Fig 6. It is assumed that the receiver has been set for reception of a selected service on a first central frequency f_{C1} when the illustrated procedure starts. In the Fig 8 embodiment the selected service is received in the normal manner, as illustrated by step S600. Hence, step S600 may involve the above described method steps S510, S520, S530, S540, and the reception quality is continuously monitored (S610) in any of the above mentioned manners.

If the reception quality falls below an acceptable level the processor 410 will use the received current TII code for reading the content of the "alternative frequencies" data field, illustrated in table 2, for information about alternative frequencies (S620),

and thereafter the receiver will test reception on one or several of the indicated alternative frequencies (S630).

An alternative which provides a good reception quality will be selected (S640), and the procedure continues with step S600 again. If, on the other hand, none of the alternative frequencies according to the list provides a good reception quality the receiver will instead proceed with step S650.

In step S650 the receiver will scan all frequencies in search for a service of the selected type (e.g. S1). When a signal has been found the receiver will proceed with the reception quality evaluation according to step S630.

According to another embodiment the receiver is set up to operate in the most efficient manner whether the transmitter delivers one or several alternative frequencies. In order to obtain that objective, the computer program in memory 450 (Fig. 6) causes the processing unit 410 to evaluate the content of the "alternative frequencies" data field for establishing whether the data field associated with the current transmitter identification code includes plural alternative central frequencies or a single alternative central frequency. When the list includes a single alternative central frequency (f_{C2}), the data processing unit 410, directed by the program, causes the RF circuit (320) to perform a frequency change so as to continue reception of the selected service on that central frequency; and when the "alternative frequencies" data field includes plural alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}), the data processing unit (410) is set up to cause the RF circuit (320) to perform at least one test reception (S630), for evaluation of the reception quality so as to select (S610) an alternative central frequency providing an acceptable reception quality.

Claims

1. A method for frequency tracking in a digital broadcasting system comprising a plurality of broadcasting transmitter stations (10) for transmitting a service to a mobile broadcast receiver (30);

the method comprising the steps of :

transmitting, from a certain broadcasting transmitter station (10), said service using a first central frequency (f_{C1});

transmitting, from said certain broadcasting transmitter station (10), information identifying said certain transmitter;

transmitting, together with said service, a list comprising transmitter identification codes and associated alternative frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) on which said service is transmitted;

characterized by

transmitting , in a first directional sector from said certain broadcasting transmitter station, a first transmitter identification code (A); and

transmitting , in a second directional sector from said certain broadcasting transmitter station, a second transmitter identification code (B), said second transmitter identification code (B) differing from said first transmitter identification code (A); wherein

said list associates said first transmitter identification code (A) with a first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}), and

said list associates said second transmitter identification code (B) with a second set of alternative central frequencies (f_{C2}; f_{C3}; f_{C4}), said second set of alternative central frequencies (f_{C2}; f_{C3}; f_{C4}) differing from said first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}).

2. The method according to claim 1, **characterized in that**

said first set of alternative central frequencies is limited to a single alternative central frequency (f_{C2}).

3. The method according to 2, **characterized by**

transmitting, from a second broadcasting transmitter station located within an extension (210) of said first directional sector from said certain broadcasting transmitter station (10), said service using said one alternative central frequency (f_{C2}).

4. The method according to any of claims 1, 2 or 3, **characterized by**

generating, in said certain broadcasting transmitter station (10), a radio frequency signal comprising said service and said list;

delivering said radio frequency signal to a plurality of transmission units (100);

adding mutually different transmitter identification codes (A, B, C) to said radio frequency signal in the mutually different transmission units (100A, 100B, 100C) so as to generate a plurality of transmission signals (S_{DABA}, S_{DABB}, S_{DABC}) being substantially identical except for the transmitter identification code;

transmitting said plurality of transmission signals (S_{DABA}, S_{DABB}, S_{DABC}) in mutually different directions.

5. The method according to 1, further comprising the steps of:

receiving, in said mobile broadcast receiver (30), information including a selected service from at least one of a plurality of broadcasting transmitter stations (10) using a first central frequency (f_{C1});

extracting service identity information (S1) associated with said service;

extracting a list comprising transmitter identification codes (A, B,C, D, E, F) and associated alternative frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) on which said service is transmitted;

extracting a currently received transmitter identification code (TII);

monitoring the quality of reception on said first central frequency (f_{C1}); and

using the list of alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) such that

when the monitored quality falls below a threshold value and the currently received transmitter identification code (A) is associated with the first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}) the broadcast receiver (30) performs a test reception using said first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}); and

when the monitored quality falls below the threshold value and the currently received transmitter identification code (B) is associated with the second set of alternative central frequencies (f_{C2}; f_{C3}; f_{C4}) the broadcast receiver (30) performs a test reception using said second set of alternative central frequencies.

6. The method according to 2, further comprising the steps of:

receiving, in said mobile broadcast receiver (30), information including a selected service from at least one of a plurality of broadcasting transmitter stations (10) using a first central frequency (f_{C1});

extracting service identity information (S1) associated with said service;

extracting a list comprising transmitter identification codes and associated alternative frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) on which said service is transmitted;

extracting a currently received transmitter identification code (TII);

monitoring the quality of reception on said first central frequency (f_{C1}); and

using the list of alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) such that when one transmitter identification code (A) is associated with one alternative central frequency (f_{C2}) the broadcast receiver (30) performs a frequency change to reception on the alternative central frequency (f_{C2}) associated with the currently received transmitter identification code (A) when the monitored quality falls below a certain threshold value.

7. The method according to claim 6, **characterized by** the steps of:

evaluating (S590) the list for establishing whether the received list includes a single alternative central frequency (f_{C2}) or plural alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) associated with the current transmitter identification code;

performing a frequency change so as to continue reception of the selected service on the alternative central frequency (f_{C3}) when the list includes a single alternative central frequency (f_{C2});

performing at least one test reception (S600), when the list includes plural alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}), for evaluating the reception quality of the plural alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) so as to select (S610) an alternative central frequency providing an acceptable reception quality.

8. A broadcasting transmitter station (10) for digitally transmitting a service to a mobile broadcast receiver (30), comprising:

means (40, 42, 44, 46, 48, 50, 52, 54, 60, 70) for transmitting a service using a first central frequency (f_{C1});

means (82, 70) for transmitting service identity information (S1) together with said service;

means (120) for transmitting information identifying said transmitter;

means (82, 70) for transmitting, together with said service, a list comprising transmitter identification codes and associated alternative frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) on which said service is transmitted;

characterized by

means (120A, 140A) for transmitting , in a first directional sector from said certain broadcasting transmitter station, a first transmitter identification code (A); and

means (120B, 140B) for transmitting , in a second directional sector from said certain broadcasting transmitter station, a second transmitter identification code (B), said second transmitter identification code (B) differing from said first transmitter identification code (A); wherein

said means (82, 70) for transmitting said list is set up to associate said first transmitter identification code (A) with a first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}), and

said means (82, 70) for transmitting said list is set up to associate said second transmitter identification code (B) with a second set of alternative central frequencies (f_{C2}; f_{C3}; f_{C4}), said second set of alternative central frequencies (f_{C2}; f_{C3}; f_{C4}) differing from said first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}).

9. The broadcasting transmitter station (10) according to claim 8, wherein

said means (82, 70) for transmitting said list is set up to associate said first transmitter identification code (A) with a single alternative central frequency (f_{C2}).

10. A broadcast receiver (30) set up for receiving a service; comprising

an antenna for receiving a digitally transmitted service from at least one of a plurality of broadcasting transmitter stations (10);

an RF circuit (320), coupled to the antenna, for selection of a central frequency (f_{C1}) to be received by the broadcast receiver (30) for receiving said service, said RF circuit having a control input (480) for receiving a central frequency control signal;

a data processing unit (410) coupled to the control input (480) such that selection of the central frequency to be received can be controlled by the data processing unit;

a demultiplexer unit (360) coupled to the RF circuit (320) for extracting service identity information (S1) associated with said service, and for extracting information about alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7});

an extraction device (345) for extracting a currently received transmitter identification code (TII);

a quality monitor (340, 470, 410) for monitoring the quality of reception of the selected service so as to initiate a frequency change when the monitored quality falls below a certain threshold value;

characterized in that

the data processing unit (410) is capable of storing the information about alternative central frequencies such that a first transmitter identification code (A) is associated with a first set of alternative central frequencies (f_{C2}; f_{C3}; f_{C7}), and such that a second transmitter identification code (B) is associated with a second set of alternative central frequencies (f_{C2}; f_{C3}; f_{C4}); wherein

the data processing unit (410) co-operates with the quality monitor and the RF circuit (320) so as to cause the broadcast receiver (30) to perform a quality initiated frequency change to reception on a central frequency in the first set (f_{C2}; f_{C3}; f_{C7}) when the currently received transmitter identification code is the first transmitter identification code (A); and so as to cause the broadcast receiver (30) to perform a quality initiated frequency change to reception on a central frequency in the second set (f_{C2}; f_{C3}; f_{C4}) when the currently received transmitter identification code is the second transmitter identification code (B).

11. The broadcast receiver according to claim 10, **characterized in that**:

the data processing unit (410) is set up to evaluate (S590) the list for establishing whether the received list includes a single alternative central frequency (f_{C2}) or plural alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}) associated with the current transmitter identification code, such that

when the list includes a single alternative central frequency (f_{C2}), the data processing unit (410) is set up to cause the RF circuit (320) to perform a frequency change so as to continue reception of the selected service on that central frequency (f_{C2}); and such that

when the list includes plural alternative central frequencies (f_{C2}, f_{C3} f_{C4}, f_{C5}, f_{C6}, f_{C7}), the data processing unit (410) is set up to cause the RF circuit (320) to perform at least one test reception (S630), for evaluation of the reception quality so as to select (S610) an alternative central frequency providing an acceptable reception quality.

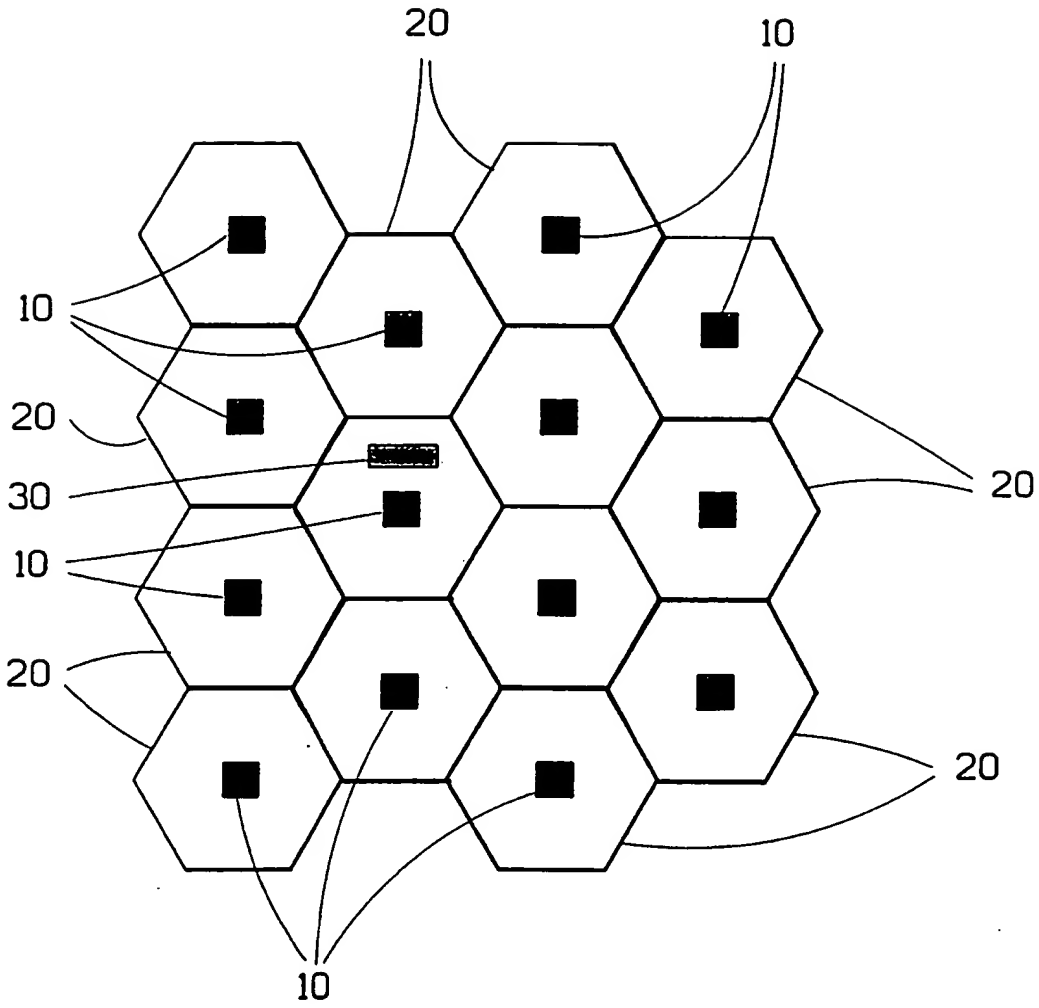


FIG.1

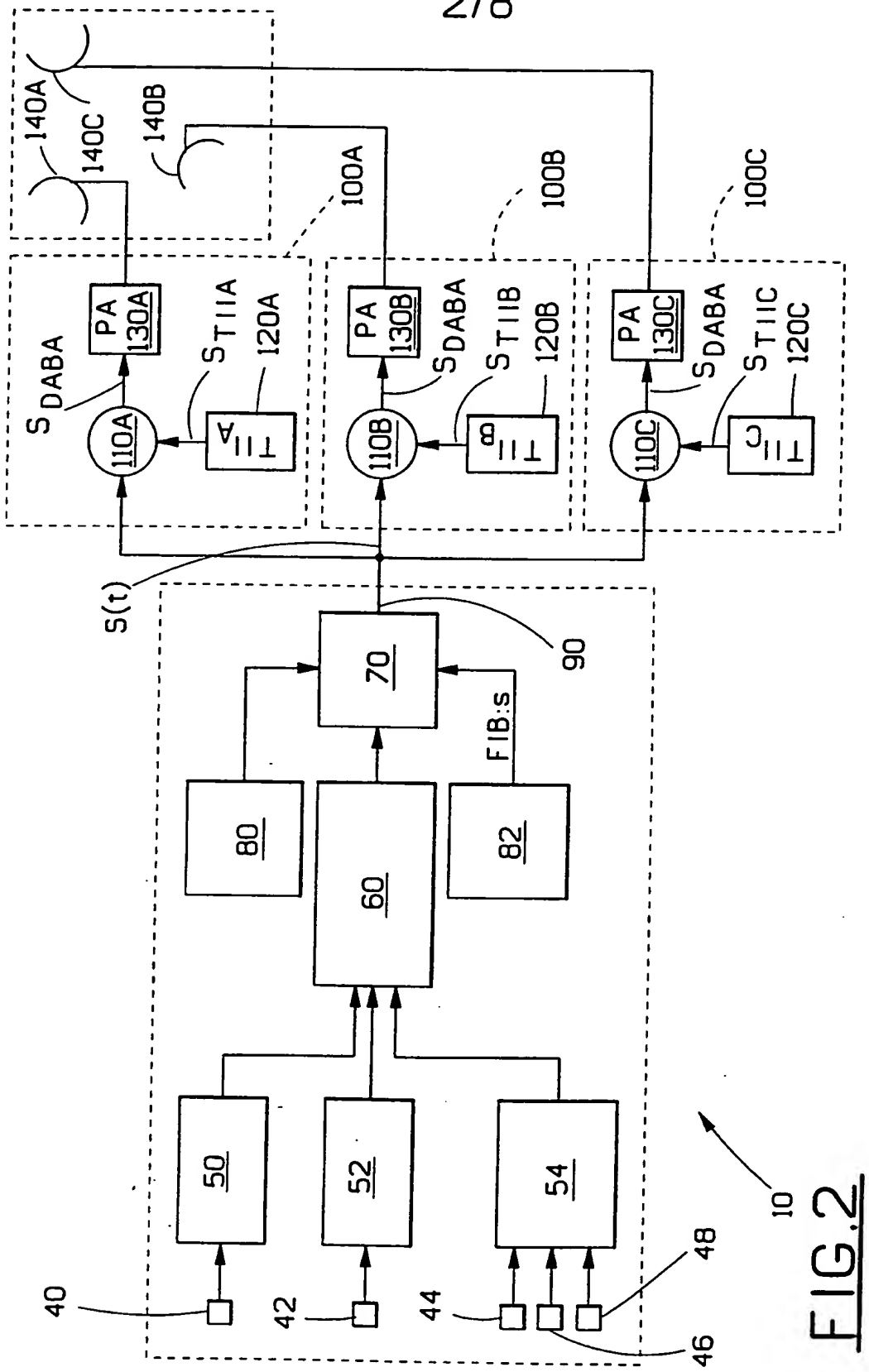

140A
140C
140B
100A
100B
100C
PA 130A
PA 130B
PA 130C
S DABA
S TIIA
120A
S TIIB
120B
S TIIC
120C
110A
110B
110C
S(t)
90
70
FIB:s
80
60
82
50
52
54
10
40
42
44
46
48

FIG.2

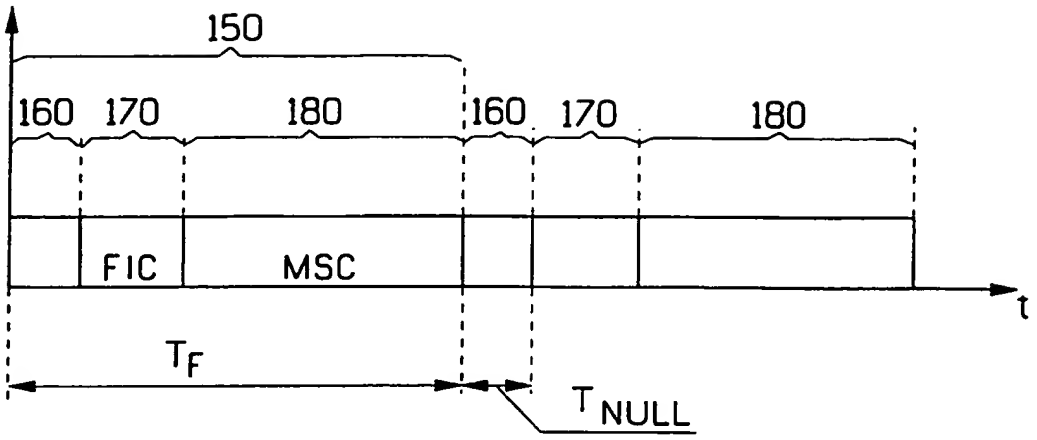


FIG.3

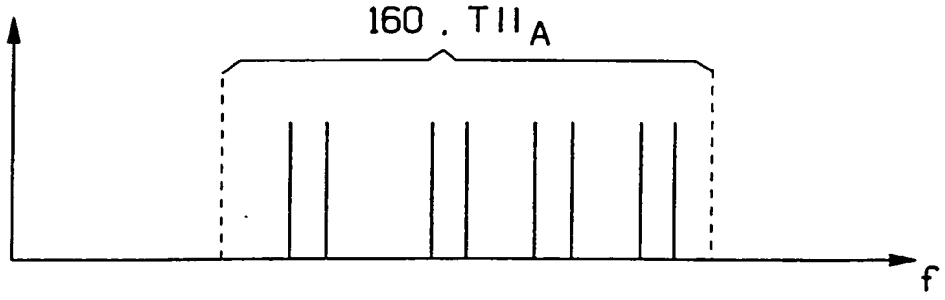


FIG.4A

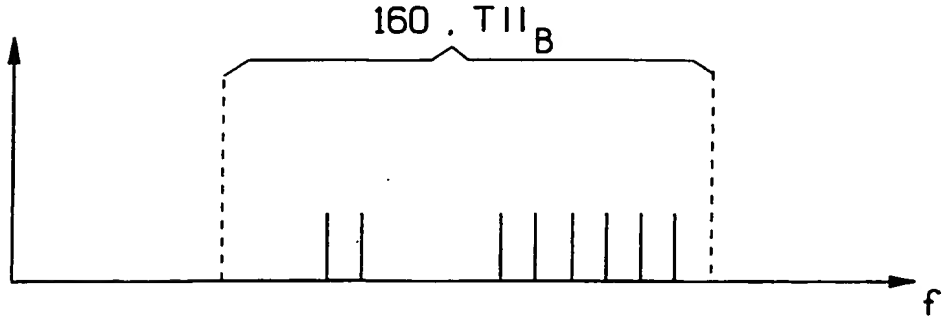


FIG.4B

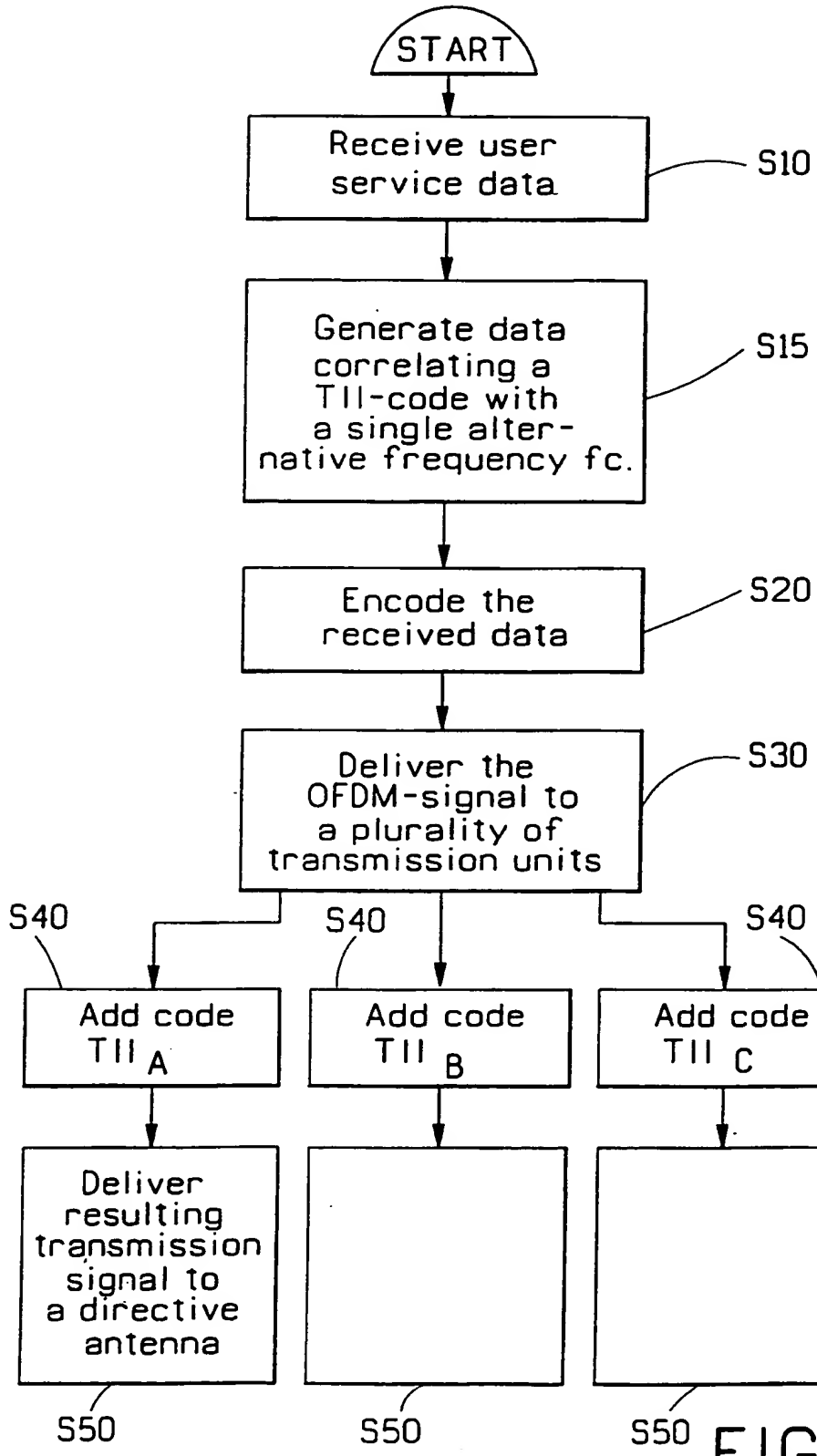

START
Receive user service data
S10
Generate data correlating a TII-code with a single alternative frequency fc.
S15
Encode the received data
S20
Deliver the OFDM-signal to a plurality of transmission units
S30
S40
S40
S40
Add code TII A
Add code TII B
Add code TII C
Deliver resulting transmission signal to a directive antenna
S50
S50
S50

FIG.4C

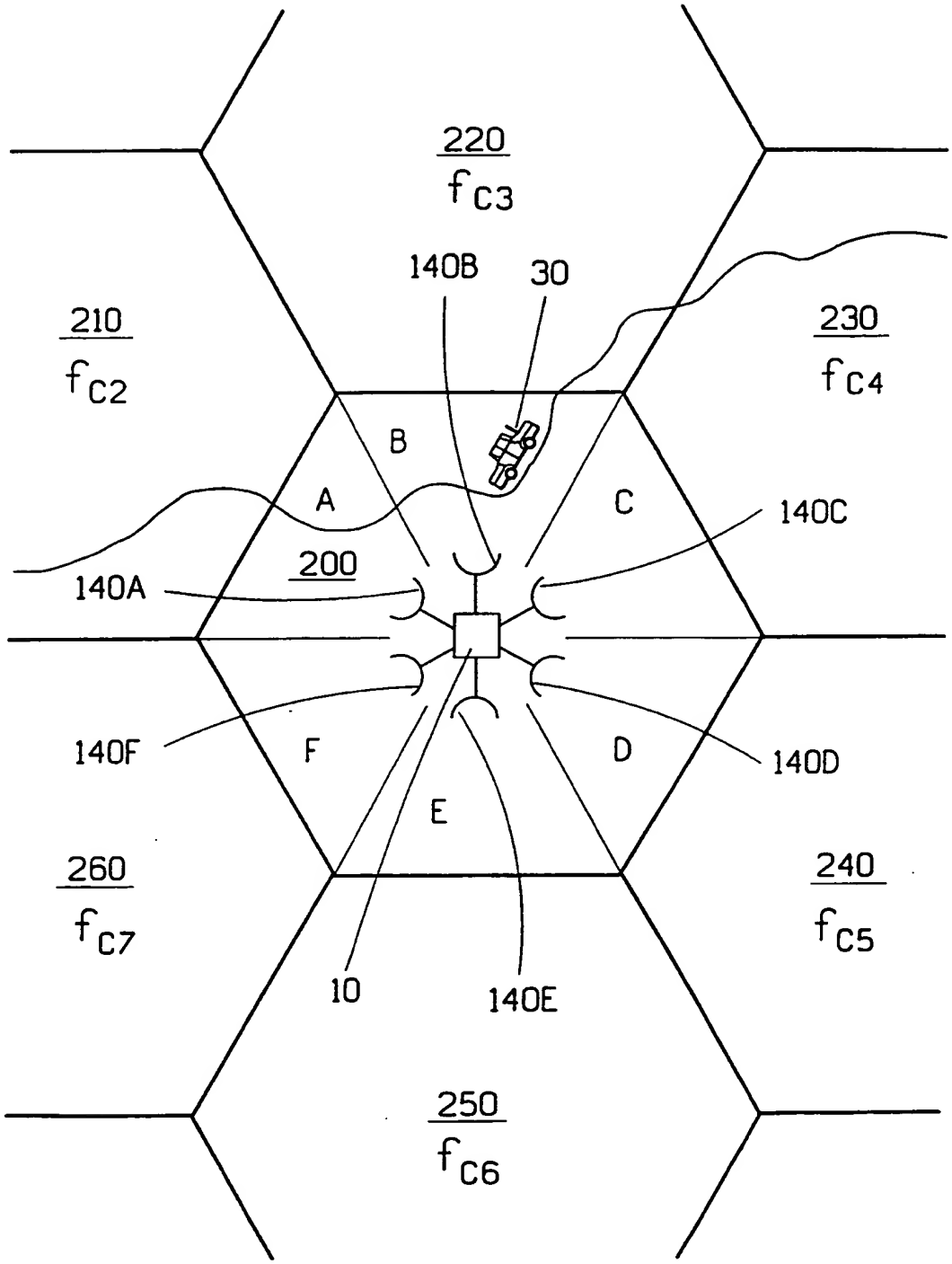

220
f_{C3}
140B
30
210
f_{C2}
230
f_{C4}
B
A
C
140C
200
140A
140F
F
D
140D
E
260
f_{C7}
240
f_{C5}
10
140E
250
f_{C6}

FIG.5

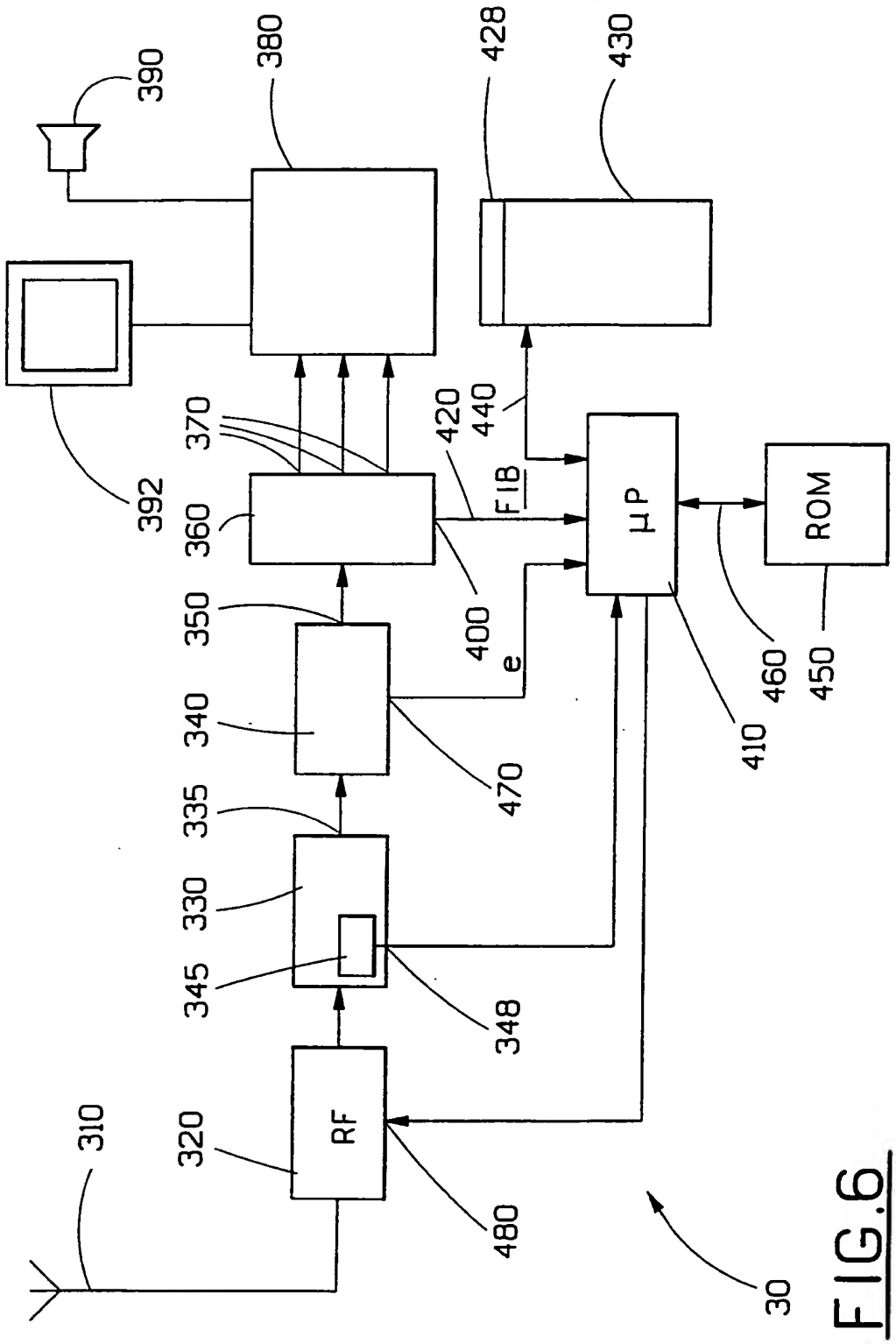

390
380
428
430
392
370
360
420
440
FIB
μP
ROM
400
e
350
340
470
460
450
410
335
330
345
348
310
320
RF
480
30

FIG.6

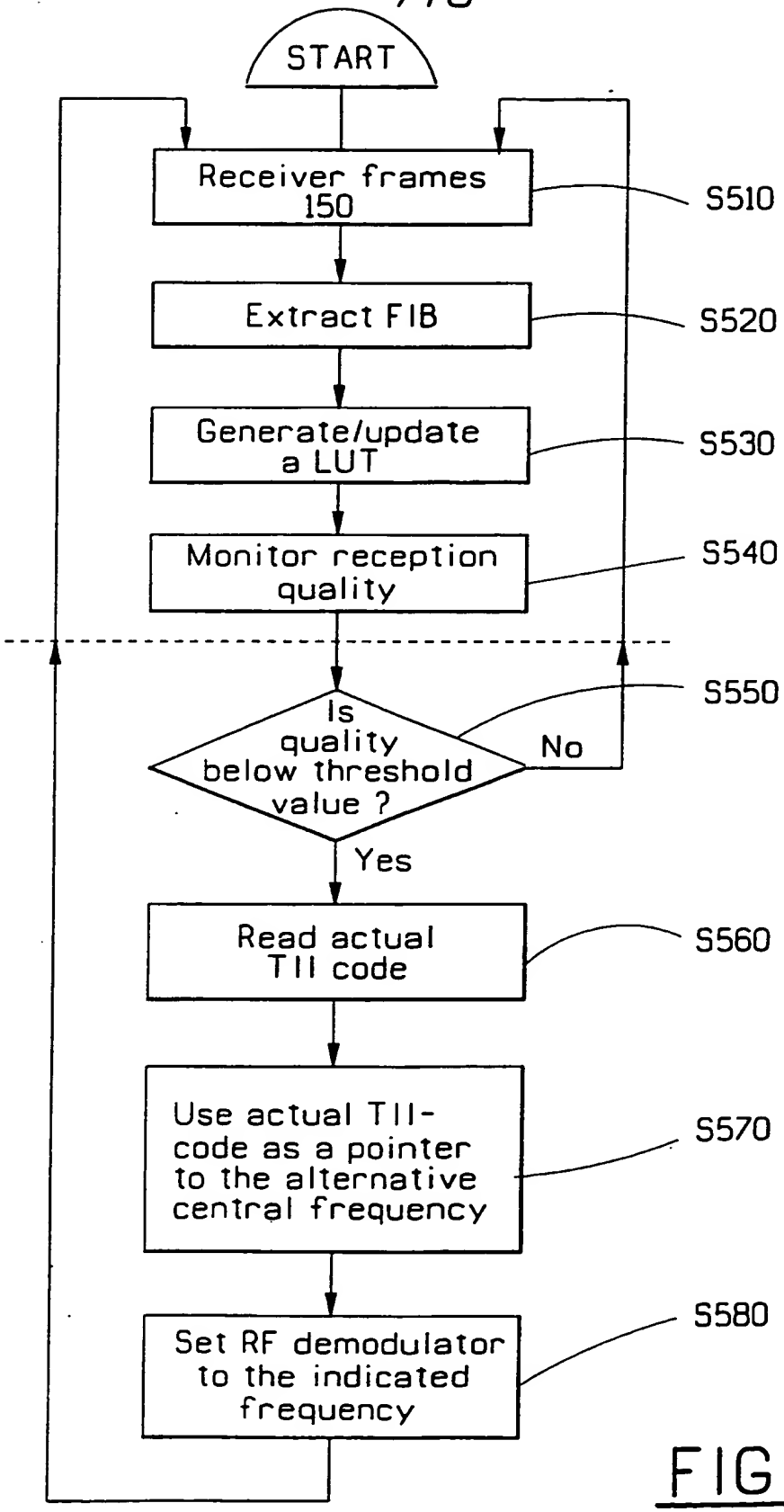

START
Receiver frames 150
S510
Extract FIB
S520
Generate/update a LUT
S530
Monitor reception quality
S540
Is quality below threshold value ?
S550
No
Yes
Read actual TII code
S560
Use actual TII-code as a pointer to the alternative central frequency
S570
Set RF demodulator to the indicated frequency
S580

FIG.7

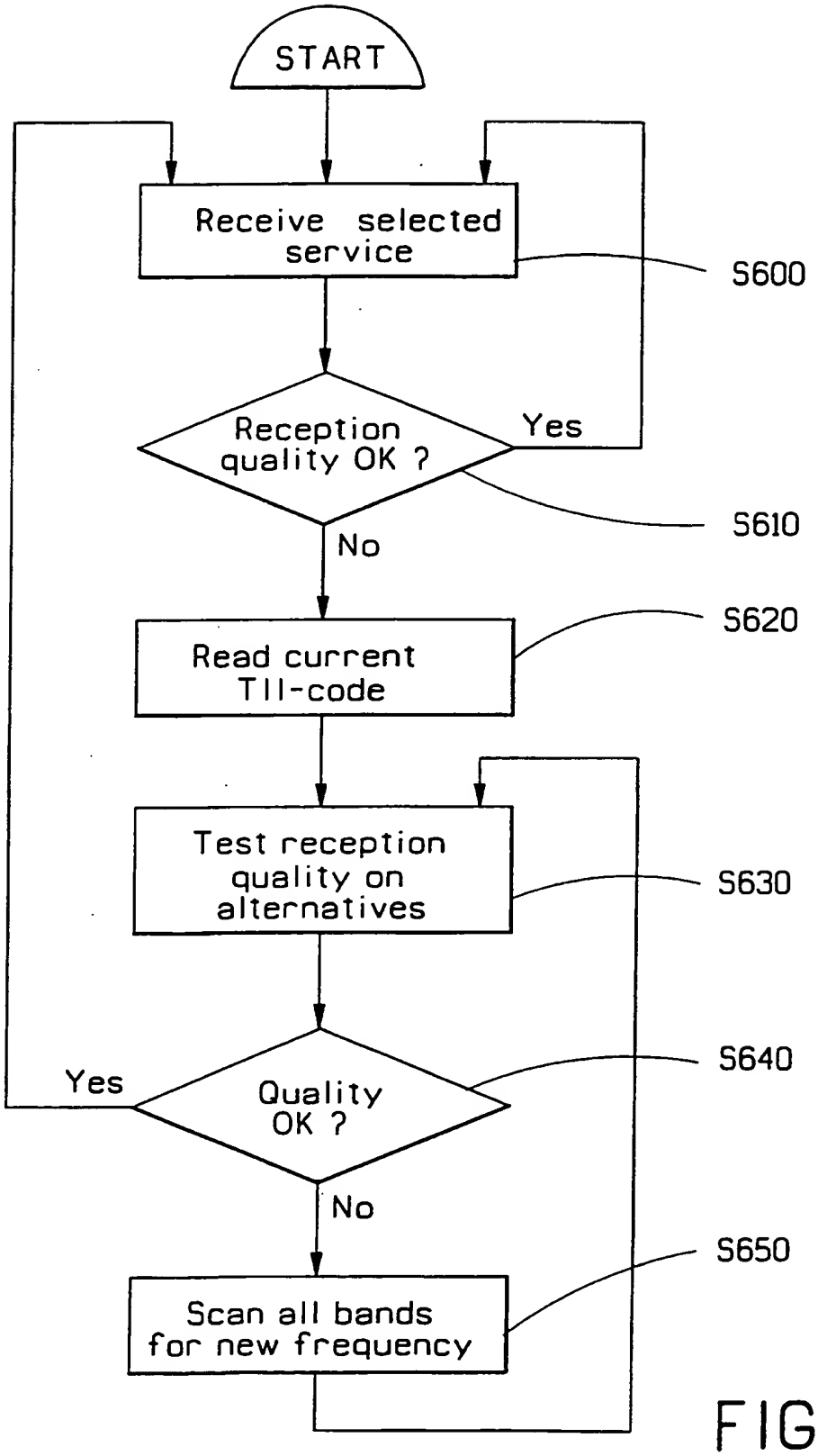

START
Receive selected service
S600
Reception quality OK ?
Yes
S610
No
Read current TII-code
S620
Test reception quality on alternatives
S630
Quality OK ?
S640
Yes
No
Scan all bands for new frequency
S650

FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01732

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04H 1/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04H, H04Q, H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0994586 A1 (SONY INTERNATIONAL (EUROPE) GMBH), 19 April 2000 (19.04.00), column 1; column 2, line 1 - line 9; column 4, line 25 - line 53, abstract --	1-11
A	EP 0476826 A2 (MITSUBISHI DENKI KABUSHIKI KAISHA), 25 March 1992 (25.03.92), page 3, line 38 - line 42, tabell 1 sid 4 figur 3 --	1-11
A	WO 9914874 A1 (TERACOM AB), 25 March 1999 (25.03.99), abstract -- --------	1-11

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 November 2000	21 -11- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Irma Bornhede/MN Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

03/10/00

International application No.
PCT/SE 00/01732

EP	0994586	A1	19/04/00	NONE		
EP	0476826	A2	25/03/92	SE	0476826	T3
				DE	69114238	D,T 21/03/96
				JP	2658538	B 30/09/97
				JP	4123510	A 23/04/92
				US	5428825	A 27/06/95
WO	9914874	A1	25/03/99	AU	9101998	A 05/04/99
				EP	1032994	A 06/09/00
				SE	9703331	D 00/00/00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01732

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04H 1/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04H, H04Q, H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 0476826 A2 (MITSUBISHI DENKI KABUSHIKI KAISHA), 25 March 1992 (25.03.92), page 3, line 38 - line 42, tabell 1 sid 4 figur 3 --	1-11
A	WO 9914874 A1 (TERACOM AB), 25 March 1999 (25.03.99), abstract -- --------	1-11

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Date of the actual completion of the international search	Date of mailing of the international search report
13 November 2000	21 -11- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Irma Bornhede/MN Telephone No. +46 8 782 25 00

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EP	0994586	A1	19/04/00	NONE		
EP	0476826	A2	25/03/92	SE	0476826	T3
				DE	69114238	D,T 21/03/96
				JP	2658538	B 30/09/97
				JP	4123510	A 23/04/92
				US	5428825	A 27/06/95
WO	9914874	A1	25/03/99	AU	9101998	A 05/04/99
				EP	1032994	A 06/09/00
				SE	9703331	D 00/00/00

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